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AUTHOR Thompson, Velma M.; Thompson, Earl A.
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ABSTRACT

This paper critiques the 1973 Spence-Arrow model of employer decision-making based on using the job applicant's educational credentials as a screening device to identify pre-existing differences in the abilities of prospective workers. The first section of the paper develops a model similar to the Spence-Arrow model, dropping the assumption that additional education always communicates a higher innate ability to work. The second section extends the critique established in the first part, and the final section of the paper presents a test of alternative models using data from a sample of World War Two veterans. (IH)

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Velma M. Thompson
Earl A. Thompson

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ON THE EFFICIENCY OF A COMPETITIVE EQUILIBRIUM WITH EDUCATION AS A SCREENING DEVICE

Velma M. Thompson and Earl A. Thompson*

In a recent series of articles, A. Michael Spence (1973, 1974) and Kenneth J. Arrow (1973) present models in which an employer hiring under uncertainty about applicants' productivities uses education to identify (screen) pre-existing differences in abilities of prospective workers. The central result of the models is that competitive equilibrium amounts of education purchased by prospective workers exceed Pareto optimal amounts. The economic argument leading to this result is that individuals place a *positive* private value on the kind of education which merely demonstrates their innately superior labor productivity and thereby serves merely to transfer to them wages which otherwise would have gone to other workers.

The purpose of this paper is to demonstrate that the Spence-Arrow conclusion fails once we drop a tacit, highly unrealistic assumption of their analysis. The assumption is that while unexpectedly good educational performance by prospective workers is communicated to employers, unexpectedly poor levels of educational performance are not. The reason the assumption is so unrealistic is that since education typically serves to increase an individual's work productivity as well as to screen him for natural ability to work, even workers with lower than expected educational performance typically will want to present evidence to employers of their having attained a particular level of education and in so doing they normally will communicate the fact of their somewhat disappointing performance.

In Section I of this paper, we develop a model which does not differ in any substantial way from those of Spence-Arrow except in that we drop the assumption that additional education always communicates a higher innate ability to work. We then demonstrate that when all levels of educational performance are communicated to employers, the prospective worker will under- or overinvest in education relative to the Pareto optimal amount, depending upon whether the prospective worker is, respectively, less or more optimistic about his natural ability than the most optimistic of his potential employers. Thus, there is little reason to suppose that there is any systematic over-

*The Rand Corporation and the University of California at Los Angeles, respectively.

valuation of education by prospective workers. We also examine a model of a signalling equilibrium, in which rational expectations are solutions rather than parameters, and again find little reason to suppose that employers are systematically more pessimistic than the workers about the workers' innate levels of skill.

In Section II, we note that our amended Spence-Arrow model, like the Spence-Arrow models, is incomplete in that it does not determine who are the employers and who are the employees. We then complete the amended model by determining the identity of the employers, and demonstrate that in our completed, amended model there is *always underinvestment* in education in any competitive equilibrium.

Section III presents a test of the alternative models using data from a sample of World War II veterans.

I. THE AMENDED MODEL

A. THE BASIC TECHNOLOGICAL AND INFORMATIONAL ENVIRONMENT

We shall consider a world containing several, technologically identical, constant returns firms with employers producing a single, homogeneous output with a single input, labor. There are also several workers in the population who differ according to their innate abilities to provide labor services. Each prospective employee and all employers have their own subjective probability distribution over the possible levels of innate ability to work of the prospective employee, where an individual's innate (or natural) ability to work is a fixed parameter which determines his work productivity for a given amount of education. Everyone is risk-neutral. An individual's innate ability to work may be discovered after the individual has been employed for a period of time, but contract costs prohibit the use of a contract which would compensate a worker for past productivity and thus guarantee him an income equal to the value of his product in the firm. Education is a resource-using activity which both (1) screens prospective workers, i.e., improves information about the innate abilities to work of prospective employees, and (2) increases prospective workers' productivities by amounts known to all.[1] Education is available at a fixed resource cost per unit, and there are nonincreasing returns to both forms of education. The amount of time each individual devotes to work plus education is fixed.

It is obvious that any investment in education for screening purposes in this model is socially wasteful, since there is a zero social

[1] The combination of perfect knowledge of the latter effect and imperfect knowledge of the former implies that the worker's productivity is an additive function of his acquired and innate productivities. We are excluding uncertainty over the effects of education in increasing a worker's productivity here only in order to isolate the screening component of education so as to facilitate comparison to the models of Arrow and Spence.

return to information about a prospective employee's innate ability to work. In a Pareto optimum, education is carried out only to the point that the marginal resource cost of education equals the value of the marginal increase in worker productivity which the education creates.

The above environment differs in no substantial way from that of Spence or Arrow. But we shall not make the Spence-Arrow assumption that additional education always indicates higher innate ability to work. Rather, we assume that the evidence of an individual's having completed a certain educational level is accompanied by a record of the quality of his past educational performance, and that his expected, innate work productivity rises or falls with additional education according as his performance in the extra education is better or worse than expected, given his prior educational record. A prospective worker who completed 12 grades with all A's and worked rather than going to junior college may be thought by employers to have a higher expected product than a prospective worker who has completed 13 grades with all A's in the first 12 grades and all C's in the 13th grade.

B. THE OPTIMALITY CHARACTERISTICS OF A COMPETITIVE EQUILIBRIUM

We assume a private property system with competitive markets for labor and education. Thus, employers maximize expected profits for given real wages and workers rationally choose an amount of education and work which maximizes their wealths, given their real wages and the costs and expected wage changes induced by additional education. Relative prices which make these individually rational decisions mutually consistent are called equilibrium relative prices, and the corresponding behavior is called an equilibrium.

When an individual undergoes an additional unit of education, he gives up the marginal resource cost of the education, receives the increase in his productivity which the education is known to create, and either benefits or suffers from the effect of the new evidence regarding his innate ability on his real wage. If the prospective worker's expectation of the latter effect is zero, his equilibrium decision is obviously to acquire education up to the point that the

marginal increase in the value of worker productivity from the education equals the marginal cost of the education. This is, as we have stated, his Pareto optimal amount of education. Thus, when each worker's own expected productivity equals the employers' expectations as measured by his current wage offer, the equilibrium is an optimum.

If the worker expects that the new evidence regarding his innate ability which further education produces will reduce his wage offer--a reduction which seems very likely because the new evidence gives the *relevant* employers, those most optimistic about his productivity, a dose of reality--then the worker will underinvest in education because of the negative effect he expects it to have on the most optimistic view of his productivity. If the worker expects that the new evidence generated by education can only increase his wage offer, he will overeducate himself. The Spence-Arrow models admit only the latter possibility because they ignore the possibility of a negative effect of the quality of a student's educational performance on the evaluation of his innate ability to work.[2]

An information structure frequently assumed by Spence has all workers knowing their own innate ability to work with certainty and all employers able to distinguish these innate abilities upon initial hiring *only* by observing different educational performances. He adds the assumption that workers with the same innate ability to work all have the same, unique costs of education and that these costs are uniformly lower for innately superior workers. It follows that if employers expect workers to have no more than the minimum productivity level implied by their level of education, their expectation is

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[2] J. E. Stiglitz mentions the possibility that individuals who "are very risk averse and not perfectly certain of their abilities" may prefer to accept an average wage rather than to undertake the chance of being screened and labelled below average. Stiglitz does not attempt to relate this possibility to the Spence-Arrow approach and is apparently unaware that the Spence-Arrow analysis assumes away the possibility that education may reveal one's lack of innate ability. As demonstrated above, no degree of risk aversion is necessary for there to be too little expenditure on screening. J. E. Stiglitz, "The Theory of 'Screening', Education, and the Distribution of Income," Cowles Foundation Discussion Paper No. 354.

fulfilled, and a "signalling equilibrium" is said to exist, as all but the worst workers will respond to these pessimistic evaluations by acquiring education until the additional cost of the education to the next-worse group of workers just equals the increased value of the productivity that the additional education indicates.[3] Thus, the employer skepticism in Spence's model with a signalling equilibrium is self-justifying, as the employees who are relatively productive acquire education in order to avoid receiving the wage of the lower productivity workers. But if employees really had such certainty about their productivity and future employer observations really could verify an educated worker's productivity, it would appear that the worker should merely guarantee his natural ability (or relative productivity) and thereby avoid the necessity of costly screening devices. As the eventual discovery of the productivities of at least some educated workers is necessary for employers to verify their assumption that the more educated workers are their more productive ones, it is not clear why these contracts are ruled out in Spence's model. For the same reason, workers with exceptionally high natural ability, who are facing a massive waste of their resources in uneconomic education, may rationally choose to quit school and wait for employers to discover them. (Because of the financial advantage of being discovered at a young age, they may even drop out while the real productivity increases produced by additional education exceed the costs of the additional education.) Employers could not then rationally use educational attainment as a perfect screening device and would rationally become more optimistic about the innate ability of some workers than the workers themselves.

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[3] Spence's definition of equilibrium under these pessimistic expectations is similar, but not identical. Rather, he assumes that the worker is confronted with a monotonically increasing relation between education and wages. Such a relation generally fails to induce workers to cease their education once they have demonstrated their natural ability classes. Problems of existence and indeterminacy both arise under Spence's definition. (Spence recognized the latter problem, while the former was pointed out by Riley, 1974.) Such problems do not arise under the more natural definition of equilibrium given in the text above.

But even supposing that the costs of guarantee contracts are somehow prohibitive and that the date of natural discovery of a worker's productivity is sufficiently far in the future that even the most able workers choose not to allow this natural process to screen them, there is still a problem in the Spence model, which also occurs in the model of Arrow and our model above. The models are incomplete, as they do not determine the identity of the employers and the employees.

II. COMPLETING THE MODEL

In this section, we complete our amended Spence-Arrow model in order to determine who are the employers and employees. And, once the model is completed, there is never overeducation and there is generally undereducation in every competitive equilibrium.

Employers in our model are owner-decisionmakers of firms and do not use up any of their labor in their decisionmaking role. Now, an individual will be an "employer" of a given worker if and only if he outbids all other individuals including the worker for that worker's labor services. This, in turn, will happen if and only if the individual has a higher expectation of the worker's product than anyone else, including the worker himself. Correspondingly, employees are workers for whom there is some other individual in the economy with greater optimism about the worker's product. An employer may also be an employee. This happens when someone else evaluates the individual's productivity higher than he does himself, while the individual himself evaluates the product of some other individual higher than anyone else in the economy. An equilibrium set of employers is constructed by taking each worker and finding the individual who is most optimistic about his productivity. In case there are several individuals with equivalent optimism about an individual's productivity, we choose the worker's employer in some arbitrary fashion, unless one of the individuals is the worker himself, in which case we allow the individual to work for himself rather than an employer. Once we have thus considered every worker, we will have determined the distribution of workers to firms. In such an equilibrium, any time there is an employer-employee relationship, the employer is more optimistic than the employee concerning his productivity as a worker.

We now make the plausible assumption that the extra information which screening creates never reverses the sign of the difference between a worker's own expectation and anyone else's expectation of the worker's productivity. It follows that screening has no effect on the set of individuals who are the employees in the economy. It also follows that the self-employed place no value on the screening component of

their education. Prospective employees, however, given their pessimism relative to their employers about their own productivities, will expect the new evidence of their innate abilities resulting from additional education to lower their potential employers' evaluations of their innate abilities and thus serve to lower their best wage offers. Hence, the screening component of education is always responsible for under- rather than overeducation in an equilibrium in a completed Spence-Arrow model.

The fact that interpersonal technological information differences cause inefficiencies in a standard competitive model has been pointed out earlier [Hirshleifer (1971), Thompson (1966), (1971)]. The proposition here is that the presence of <u>any</u> such information difference creates a general overvaluation of productive resources by their owners because the most optimistic individuals become the owners of the resources.[4] Viewed in this way, the long-term trend toward the separation of business ownership from control, accompanied by an expanding difference in information between owners and controllers, is socially advantageous in that it has kept the more objective individuals in control of our companies. Nevertheless, the controlling individuals have too little incentive to work because, given their relative pessimism about the firms, they are unwilling to hold sufficient stock, stock options, profit shares, etc. This suggests an explanation for the government subsidy to the use of stock options and profit sharing plans in order to raise managerial work incentives to the efficient level, that which would exist if the managers were as optimistic as the owners.[5/6/]

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[4] If we go beyond the standard model and permit a perfect market for decision services by experts, then optimality is restored under certain conditions (Thompson, 1971). However, existing markets for decision services lack the requisite perfection, as it is costly to establish the benefits of a decision service for one who attempts to guarantee the benefits resulting from his decision.

[5] An overall optimum, one which also removes the general overexpansion which results from having overoptimistic owners, is a special tax on the capital of owners who are not controllers. But in a world with a corporate income tax, this may take the form of a tax-break on manager-owned stock.

[6] The power of the information-difference approach in explaining several paradoxes regarding managerial compensation and stock market behavior is being described in a UCLA Ph.D. dissertation by Tom Zorn.

III. A TEST OF THE ALTERNATIVE MODELS

Data from a sample of World War II veterans describe the percentage earnings differential over time between high school graduates and those with different levels of higher education, with measured ability held constant. This data can be used to test our completed model against the Arrow-Spence models, assuming no difference in the rates of post-education productivity growth between high school graduates and those with higher education (e.g., no difference in on-the-job training). The Spence-Arrow models imply no expected change over time in the percentage earnings differential between high school graduates and those workers with higher education, as employers come to have better information about workers' relative productivities; the relatively uneducated workers who finally obtain upward wage adjustments can be expected to be matched by similarly uneducated workers who prove to be disappointments and receive downward wage adjustments.[7] In contrast, our completed, simple model implies that the percentage earnings differential widens over time as employers learn of their initial relative overoptimism regarding the innate abilities of their relatively uneducated workers.

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[7] Layard and Psacharopoulos (1974) state that the Spence-Arrow screening hypothesis implies that the percentage earnings differential declines over time, but their view appears to be based upon a non-Spence-Arrow assumption which would have the employers irrationally adjusting wages up for the unusually productive uneducated workers without correspondingly dropping the wages of other uneducated workers.

Nevertheless, the Spence-Arrow hypothesis would imply declining differentials if it were combined with the plausible assumption that the workers with less formal education, but the same measured natural ability, obtain more training beyond formal education (relative to their levels of formal education) than their more formally educated counterparts. This assumption is especially plausible if we assume that all individuals with the same natural ability accumulate the same, optimal stock of technical knowledge, but that some accumulate it in a concentrated fashion early in their lives via formal education while others do it more gradually.

In Table 1 a comparison of the growth of earnings of those veterans who were high school graduates and those with different levels of higher education, lumped over many occupations, reveals that the earnings differential rises with work experience, a result implied by our completed model but denied by the Spence-Arrow models.

TABLE 1

Standardized Earnings and Earnings Progress of Those with Higher Education as a Percentage of Earnings of High School Graduates

Educational Attainment	Relative Earnings at Age:		Relative Earnings Progress
	33	47	
High School	100	100	0
Some College	111	117	6
B.A.	112	131	19
Some Graduate Work ..	115	126	11
M.A.	110	132	22
Ph.D.	102	127	25
M.D.	172	206	34
LL.B.	119	184	65

Source - Based on Taubman and Wales (1973, table 1). Data relate to NBER-TH sample of World War II veterans, standardized for measured ability.

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